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	Prepared by(s) Paul Dizon	Supersedes None
GLAST LAT SPECIFICATION	Subsystem/Office Calorimeter Subsystem	
Document Title **CAL Flight Module Thermal-Vacuum Test Procedure**		

REVIEW COPY

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter Flight Module 101 (FM 101)
Thermal-Vacuum Test Report

DOCUMENT APPROVAL

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
01	20 October 2004	Initial Release

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1 INTRODUCTION

1.1 PURPOSE

This report presents the results of the protoflight thermal-vacuum test performed on the GLAST Calorimeter (CAL) Module, designated as Flight Module 101 (FM 101). This test was performed on October 1-15, 2004 in accordance with LAT-PS-04455-02, *CAL Flight Module Thermal-Vacuum Test Procedure*, and work orders, WOA-01433 and WOA-01434.

1.2 OBJECTIVE

The four primary objectives of this test are:

- To verify the performance and thermal design of FM 101 over the protoflight temperature range of –30 °C to +50 °C.
- To characterize the thermal balance of FM 101 over the protoflight temperature range of –30 °C to +50 °C.
- To characterize the functional performance of FM 101 over the cold operating temperature of –5 °C

Throughout the test, functional and performance testing of the AFEE and TEM electronics is performed to verify that:

- Proper communication between TEM and CAL Module exists
- All registers of the CAL Module function properly
- Pedestal amplitude and noise in all four energy ranges remain stable
- Optical performance of each Crystal Detector Element (CDE) remains stable.

1.3 VERIFICATION

This test satisfies the requirements for verification of the GLAST CAL Module as specified in the LAT Calorimeter Verification & Environmental Test Plan, LAT-SS-01345.

2 APPLICABLE SPECIFICATIONS

Documents required to perform this test include the as-run procedure and the work orders. The applicable documents cited in this standard are listed in this section only for reference.

2.1 GOVERNMENT SPECIFICATIONS

The following specifications, standards and handbooks form a part of this document to extent specified herein.

Number	Title
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components

2.2 NON-GOVERNMENT SPECIFICATIONS

Number	Title
LAT-MD-00408	LAT Instrument Performance Verification Plan
LAT-MD-01370	CAL Comprehensive and Limited Performance Test Definition
LAT-MD-04187	CAL Electronic and Muon Calibration Definition
LAT-PS-01513	CAL Functional Test and Calibration Procedure
LAT-PS-04237	CAL Module Handling Procedure
LAT-PS-04455	CAL Flight Module Thermal-Vacuum Test Procedure
LAT-SS-00788	LAT Environmental Specification
LAT-SS-01345	LAT CAL Verification & Environmental Test Plan
LAT-SS-00971	CAL Program Quality Assurance Plan
ANSI/ESD S20.20-1999	Standard for the Development of an ESD Control Program
N/A	Instrumentation Manuals

2.3 DRAWINGS

Number	Title
LAT-DS-00916	Calorimeter Module, GLAST
LAT-DS-01643	TEM-TPS Assembly
LAT-DS-04536	Calorimeter Tower Module

2.4 ORDER OF PREFERENCE

In the event of a conflict between this document and the technical guidelines cited in other documents referenced herein, the technical guidelines of this document would take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3 TEST DECRIPTION

3.1 TEST OBJECTIVE

The objective of this test was to verify the performance of the protoflight GLAST CAL Module over the protoflight and operational temperature ranges. In addition, the thermal balance of the protoflight module was also characterized.

3.2 TEST METHODOLOGY

FM 101 was subjected to four thermal-vacuum cycles at the temperature extremes of –30 °C to +50 °C (1.0e-5 torr). The last cycle was also dedicated to thermal balance characterization. At the conclusion of the fourth cycle, FM 101 was held –5 °C, to characterize its performance at its cold operational temperature.

The test fixture, as shown in Figure 3-1, consisted of cold plates, which provide the temperature control for temperature ramp and dwell during the test. The temperature of the cold plates were managed with cooling tubes supplying liquid nitrogen and resistive heaters. The entire test article and fixture was completely thermally isolated from the walls of the thermal vacuum chamber by MLI blankets.

Functional tests that occurred in the thermal-vacuum environment are outlined below:

- Survival turn-on sequence – conducted at each hot and cold survival plateau
- Comprehensive Performance Tests (CPT) - conducted at each plateau of all test cycles
- Limited Performance Tests (LPT) - conducted during thermal transitions, where system failures or intermittent problems are most likely to occur
- Muon Collection

The thermal-vacuum test also fulfilled the bakeout function requirement since the structure was above 40 °C during a majority of the transitions. A contamination plate was also installed within the vacuum chamber during the test.

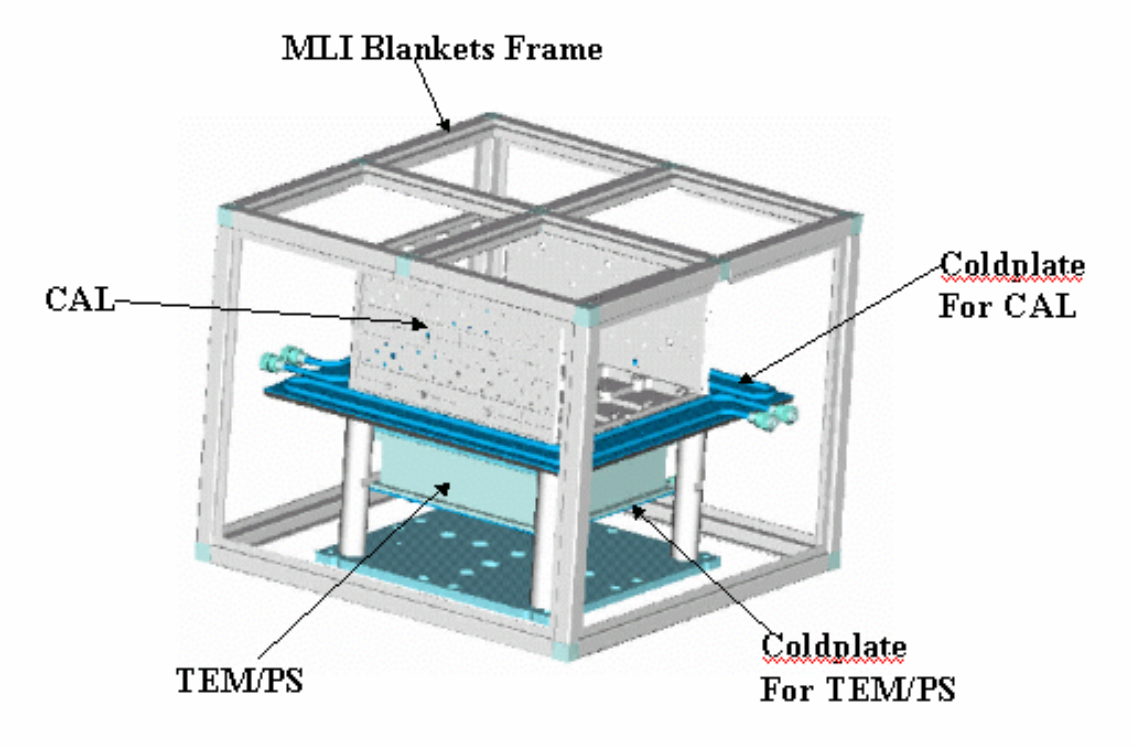


Figure 3-1: Test Fixture Set-up for Thermal Vacuum Test

(MLI Thermal Blankets Removed For Clarity)

3.3 TEST ARTICLE DESCRIPTION

The test article is the GLAST CAL Tower Module, FM 101, as documented in the as-built configuration list (ABCL) shown in Table 5-1. The CAL Tower Module (LAT-DS-04536) consists of the CAL Module (LAT-DS-00916) with the Tower Electronics Module/Power Supply (TEM/TPS) Assembly (LAT-DS-01643) attached to the CAL Module base plate by means of four rigid stand-offs.

There are no deviations from the flight configuration with the exception that the TEM/TPS Assembly is version EM2, rather than Flight. The GLAST CAL Tower Module in flight configuration is shown in Figure 3-2.

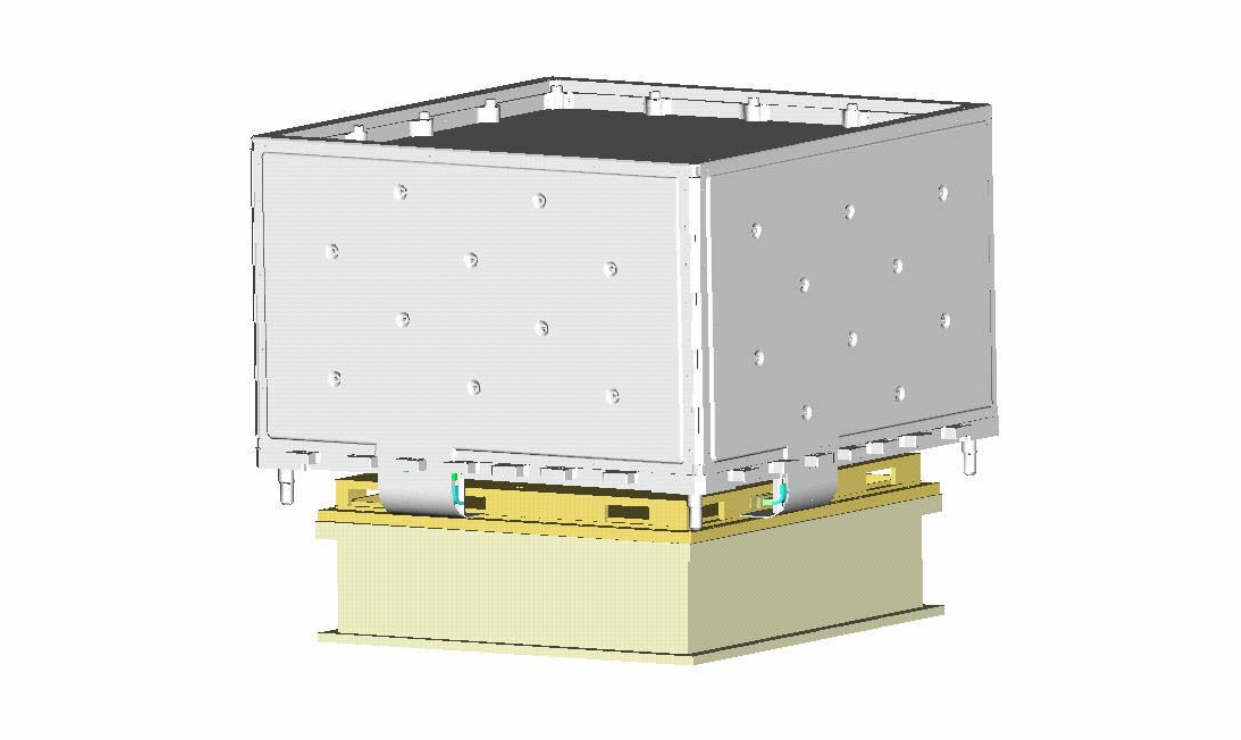


Figure 3-2: CAL in Flight Configuration with TEM/TPS

4 TEST RESPONSIBILITIES

4.1 TEST PERSONNEL

Test personnel are defined below. Responsible points of contact for this test procedure are listed in Table 4-1.

Table 4-1: Test Personnel

Role	Name	Telephone Number
Project Representative	Eric Grove	202-767-3112
Test Director	Paul Dizon	202-404-7193
Test Conductor, Primary	Mike Van Herpe	202-767-3944
Test Conductor, Electrical Subsystem	Byron Leas	202-404-1464
Test Conductor, Science Subsystem	Eric Grove	202-767-3112
Instrumentation/Data Support	Mike Van Herpe	202-767-3944
Thermal Analysis Support	Peck Sohn	301-902-4098
Electrical Subsystem Engineering Support	James Ampe	202-404-1464
Quality Assurance Support	Nick Virmani	202-767-3455
	James Lee	202-404-1476

5 GENERAL TEST PROGRAM REQUIREMENTS

5.1 TEST SETUP

5.1.1 Test Location

The thermal-vacuum test was conducted in the Thermal-Vacuum Test Laboratory (cyro-pump TVAC test chambers: North Chamber) of the Payload Check-Out Facility, Building A-59, at the Naval Research Laboratory, Washington, D.C.

5.1.2 Test Article Configuration

The As-Built Configuration List (ABCL) of the CAL Tower Module (LAT-DS-04536) in its test configuration is shown in Table 5-1.

Table 5-1: As-Built Configuration List – TVAC Test

Assembly / Component	Part Number	Status
Calorimeter Tower Module, s/n FM 101	LAT-DS-04536	Flight
TEM/TPS Assembly, s/n FM01	LAT-DS-01643	GSE
M6 Screws, Socket-Head Cap (QTY 4)	LAT-DS-04385	GSE
M6 Washers, Flat (QTY 4)	LAT-DS-04354	GSE

5.1.3 Test Equipment

The following test equipment and systems was used in the execution of this test:

- Test Chamber: North Chamber TVAC Chamber (cryo-pump)
- Test Article: FM 101 CAL Module with EM2 TEM/TPS
- Test Article Support: CAL TVAC Test Fixture with Cold Plates/MLI Blankets
  CAL Lift Fixture and Accessories
- Thermocouples: 30
- Temperature Control System: PC Computer running the CDACS TVAC software
  LN2 Solenoid Valves
  Four 50 W (CAL Cold Plate) Heaters
  Four 25 W (TPS Cold Plate) Heaters
- Data Acquisition and Control PC Computer and HP 34970A Data Acquisition/Switch Unit running the CDACS TVAC software
- Electrical Test Equipment Calorimeter Test Stand Data Acquisition Unit/GASU

The CAL Tower Module was mounted in the upright position onto the TVAC test fixture, as shown in Figure 5-1. Three cold plates provided the TVAC test environment. Two liquid nitrogen-cooled cold plates (CAL Cold Plates) were attached to the CAL Tower Module using the flight interface (tabs of the CAL Module base plate) as attachment points. Another liquid nitrogen-cooled cold plate (TPS Cold Plate) was attached to the –Z surface of the TPS. Four 50 W and four 25 W heaters were installed on the CAL Cold Plates and TPS Cold Plate, respectively. The CDACS system controlled the flow of liquid nitrogen into the coolant tubes and power to the heaters to control temperature ramp and maintain the test temperature, as required.

The TVAC test fixture was isolated from the test chamber by G-10 spacers. The entire test article and fixture was completely thermally isolated from the walls of the thermal vacuum chamber by MLI blankets. These blankets were mounted to an exterior box frame, which was also isolated from the test chamber by G-10 spacers. The MLI blankets surrounded the entire TVAC test fixture.

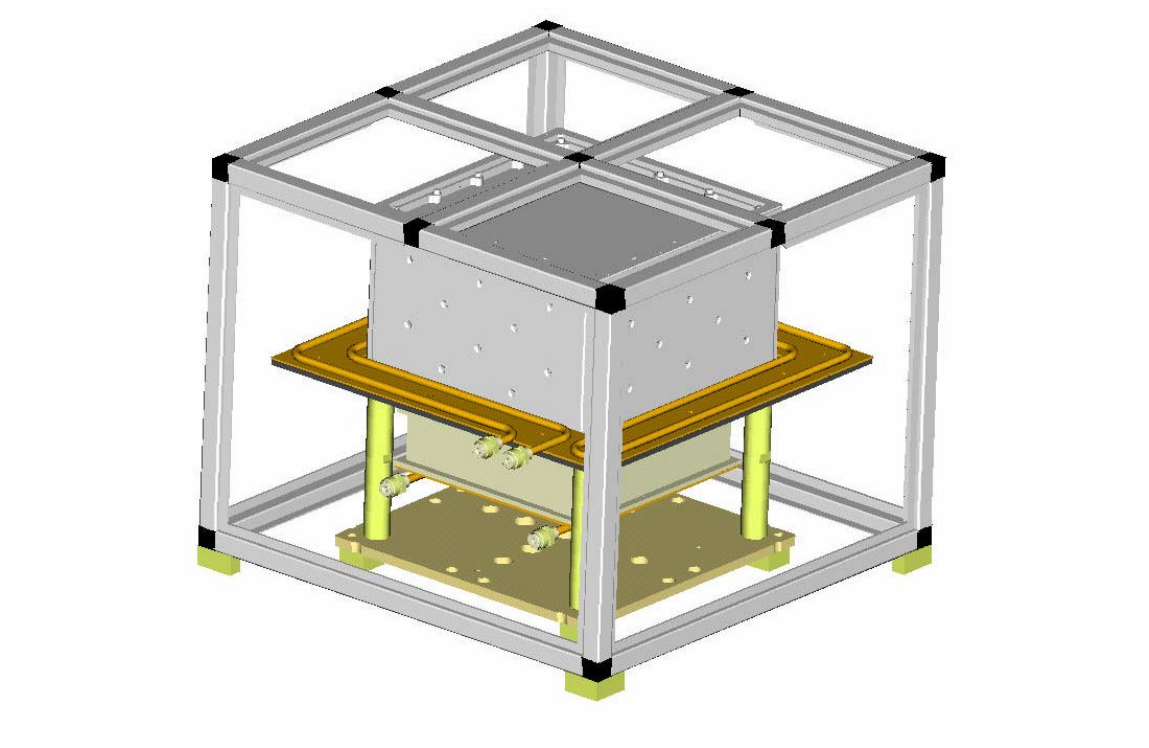


Figure 5-1: Test Fixture with CAL Module
(MLI Thermal Blankets Removed for Clarity)

5.2 INSTRUMENTATION AND DATA ACQUISITION

5.2.1 Instrumentation

Test article instrumentation consisted of external thermocouples as well as thermistors integral to the AFEE cards (one per card) and TEM-TPS (four total).

FM 101 was instrumented with 12 thermocouples (8 on the CAL Module, 4 on the TEM-TPS assembly). 18 additional thermocouples were placed onto the test fixture (CAL cold plate, TPS cold plate, and contamination plate). These additional thermocouple channels were monitored during the test in order to control the temperature environment. All thermocouple locations are listed in Table 5-2. The locations of these thermocouples are also illustrated in Figure 5.2 and Figure 5.3.

5.2.2 Calibration

Prior to testing, the thermocouples were calibrated by comparison against a standard temperature (0 °C).

5.2.3 Data Acquisition

Two data acquisition systems were used for this test:

- Dedicated PC computer and HP 34970A Data Acquisition/Switch Unit for the TVAC chamber and test article
- Calorimeter Test Stand Data Acquisition Unit for the test article electronics

A PC computer and data acquisition/switch unit running the CDACS TVAC control and data acquisition software was used to collect temperature data from thermocouples on the Flight CAL Tower Module, the test fixture (CAL cold plate and TPS cold plate), and the TVAC chamber. Temperature data was acquired at a sampling rate of 1 sample every 5 minutes. All acquired data is stored on the computer in ASCII format.

The Calorimeter Test Stand Data Acquisition Unit/GASU was used to collect science and housekeeping telemetry from the TEM of the Flight CAL Module. Temperature data from the AFEE card thermistors is imbedded in the housekeeping data stream.

Table 5-2: Thermocouple Locations for the Protoflight TVAC Test of FM 101

TC ID	Location	TC ID	Location
1	Top of Structure – Center	16	CAL Cold Plate Assembly, -Y
2	Top of Structure – Center	17	TPS Cold Plate Assembly, -X –Y
3	+X Base Plate – Bottom Center	18	TPS Cold Plate Assembly, +X –Y
4	+Y Base Plate – Bottom Center	19	CAL Cold Plate Inlet 1
5	+X Side Panel – Middle	20	CAL Cold Plate Inlet 2
6	+Y Side Panel – Middle	21	CAL Cold Plate
7	+X Base Plate – Tab	22	CAL Cold Plate Inlet 1
8	+Y Base Plate – Tab	23	CAL Cold Plate Inlet 2
9	+X TEM	24	CAL Cold Plate
10	+Y TEM	25	TPS Cold Plate Inlet 1
11	+X TPS	26	TPS Cold Plate Inlet 2
12	+Y TPS	27	TPS Cold Plate
13	CAL Cold Plate Assembly, +X	28	Contamination Plate Inlet 1
14	CAL Cold Plate Assembly, +Y	29	Contamination Plate Inlet 2
15	CAL Cold Plate Assembly, -X	30	Contamination Plate

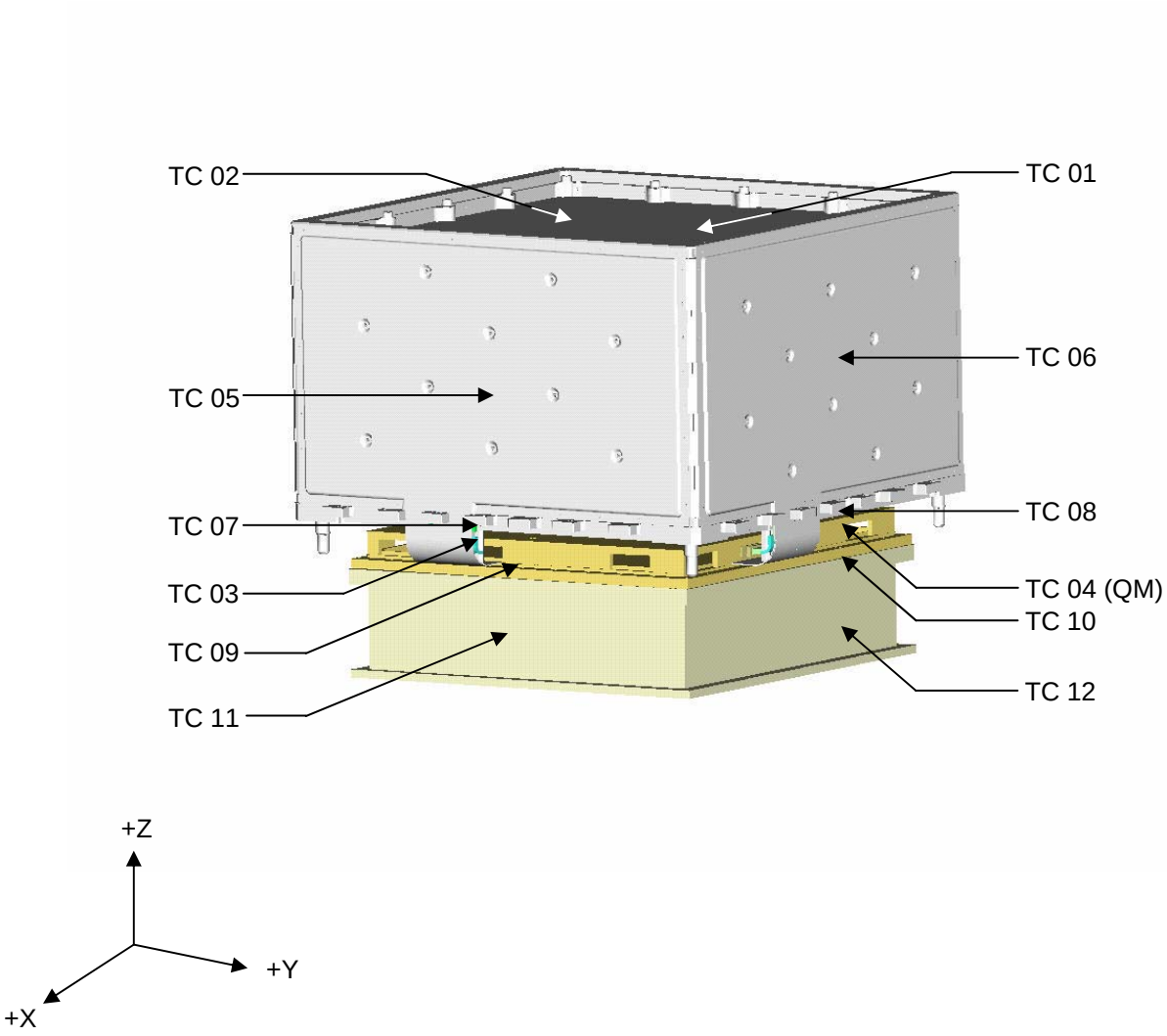
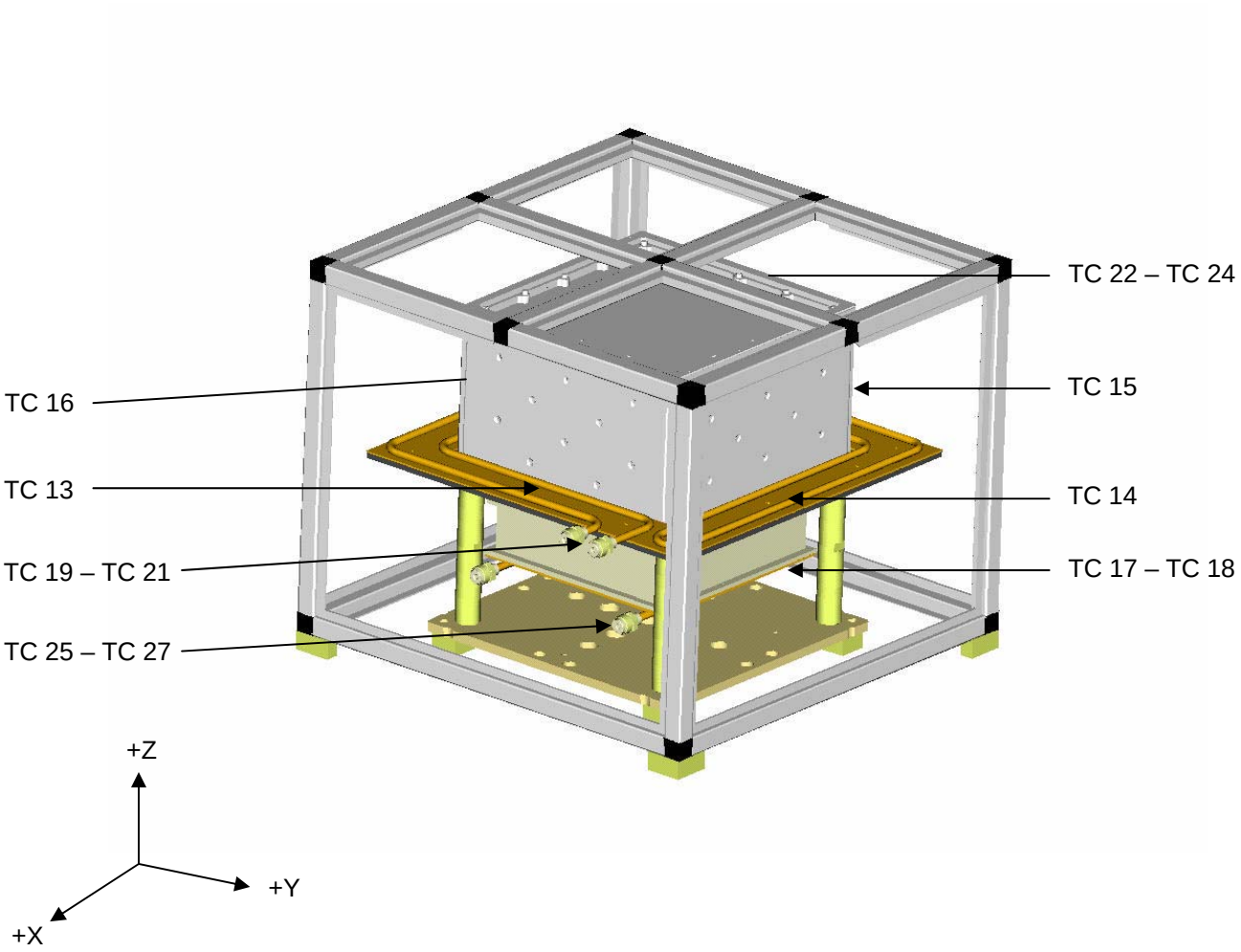


Figure 5-2: Thermocouple Locations for CAL Module Tower FM 101



NOTE: TVAC Chamber Thermocouples Not Part of Test Article

TC 28 – TC 30 (contamination plate)

Figure 5-3: Thermocouple Locations for the Test Fixture
(MLI Thermal Blankets Removed for Clarity)

5.3 VACUUM CHAMBER TEST CONDITIONS AND TOLERANCES

Prior to installation of the Flight CAL , the thermal-vacuum chamber was cleaned, by wiping all accessible surfaces of the chamber with isopropyl alcohol.

5.3.1 Environmental Conditions and Tolerances

The required test temperature levels for the CAL Module are –30 °C to +50 °C. Thermal balance was also conducted at these temperature levels. Cold operational temperature level for the CAL Module is -5 °C.

Hot soak and cold soak temperatures of the AFEE and CDEs was maintained within $\pm$ 3 °C. The TVAC test fixture and cold plate temperatures are capable of maintaining any temperature within $\pm$ 5 °C and a ramp rate no greater than 30 °C per hour. CDEs cannot exceed a ramp rate of 10 °C per hour throughout the test. Vacuum was maintained at 1.0 e-5 torr or better.

5.3.2 Thermal Balance Stabilization Criteria

Thermal balance conditions are satisfied once the average temperature of the control points are stable within $\pm$0.1 °C/hour. These control points are defined in Table 6-2. The NRL Hyman manuever, where additional heat was added or subtracted to verify steady-state, confirmed that the temperature had stabilized to $\pm$0.1 °C/hour for thermal balance testing.

5.3.3 Outgassing

All hardware used in the TVAC chamber meets the NASA outgassing requirements.

5.3.4 Temperature Limits

Throughout the test, the CAL Module and AFEE temperatures are limited +60 °C during hot soak and –40 °C during cold soak.

Per SLAC direction due to the functional performance problem at the cold temperature, the temperature of the EM2 TEM/TPS was maintained at +25 °C $\pm$10 °C.

Alarms were set in the TVAC control and data acquisition software to notify the Test Conductor with a warning message displayed on the terminal screen when test temperatures exceed their allowable high and low limits.

6 TEST PROCEDURE OVERVIEW

The thermal-vacuum test for FM 101 was divided into three phases: 1) thermal-vacuum cycling, 2) thermal balance, and 3) operational temperature function test. The thermal-vacuum test, which included electrical functional testing as well as muon performance testing, followed the temperature profile and test timeline as described in Section 6.1 and Section 6.5 of LAT-PS-04455-02, *CAL Flight Module Thermal-Vacuum Test Procedure*.

The test sequence for FM 101 is summarized as follows:

1. Installation of CAL Tower Module into the Test Fixture
2. Installation of the Test Article into the TVAC Test Chamber
    - Limited Performance Test
3. Thermal-Vacuum Cycle 1
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection
    - AFEE Card Temperature Soak
        - AFEE Card Power-Down/Up Test
        - Comprehensive Performance Test
    - 4 Hour CAL Module Temperature Soak
        - Bake-Out
        - Comprehensive Performance Test
        - Muon Collection
4. Thermal-Vacuum Cycle 2
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection
    - AFEE Card Temperature Soak
        - AFEE Card Power-Down/Up Test
        - Comprehensive Performance Test
    - 4 Hour CAL Module Temperature Soak
        - Comprehensive Performance Test
        - Muon Collection

5. Thermal-Vacuum Cycle 3
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection
    - AFEE Card Temperature Soak
        - AFEE Card Power-Down/Up Test
        - Comprehensive Performance Test
    - 4 Hour CAL Module Temperature Soak
        - Comprehensive Performance Test
        - Muon Collection
6. Thermal-Vacuum Cycle 4
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection
    - AFEE Card Temperature Soak
        - AFEE Card Power-Down/Up Test
        - Comprehensive Performance Test
    - 4 Hour CAL Module Temperature Soak
        - Comprehensive Performance Test
        - Muon Collection
    - Thermal Balance Test
7. Ramp to Ambient - Operational Temperature
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection
    - AFEE Card Temperature Soak at –5 °C
        - Comprehensive Performance Test
    - 4 Hour CAL Module Temperature Soak –5 °C
        - Comprehensive Performance Test
        - Muon Collection
8. Removal of the Test Article from the TVAC Test Chamber

6.1 TEMPERATURE PROFILE

The thermal cycling of FM 101 was conducted at the protoflight temperature range, –30 °C through +50 °C. A performance characterization test at the operational temperatures of –5 °C was also conducted after the last cycle.

The thermal-vacuum test requires 4 cycles, with the last cycle dedicated to the thermal balance characterization. The test profile is shown in Figure 6-1. Cycle 1 also fulfilled the bake-out function of the structure.

During the cold or hot soak period of each TVAC cycle, the CAL and TPS Cold Plates were set according to the temperatures in Table 6-1. The CAL and TPS Cold Plates are capable of maintaining their temperatures within $\pm$ 5 °C. To expedite the hot and cold transition from plateau to plateau, the CAL cold plate was ramped up or down by the rate of 30 °C per hour and set to maximum +60 °C for hot transition and –40 °C for cold transition before settling to the protoflight temperature ranges at the final stage of transition. According to analysis predictions, as shown in Appendix A of LAT-PS-04455-02, *CAL Flight Module Thermal-Vacuum Test Procedure*, the CAL Module and AFEE temperatures shall not exceed +60 °C (for hot tests) and –40 °C (for cold tests); and the CDE shall not exceed the transition rate requirement of 10 °C per hour throughout the test.

There are no thermocouples installed on the CDEs inside of CAL module. Based on analysis, the temperatures on the top of CAL Module and CDEs merge closely together as their temperatures reach their final stage of transition to the hot and cold plateaus. Therefore, the thermocouples attached to the top of the CAL Module are monitored as control points for tests.

During thermal balance test activities, the test fixture temperature was set in accordance with the temperatures listed in Table 6-1. Thermal balance conditions was satisfied once the average temperature of the control points, as defined in Table 6-2, were stable within 0.1 °C/hour.

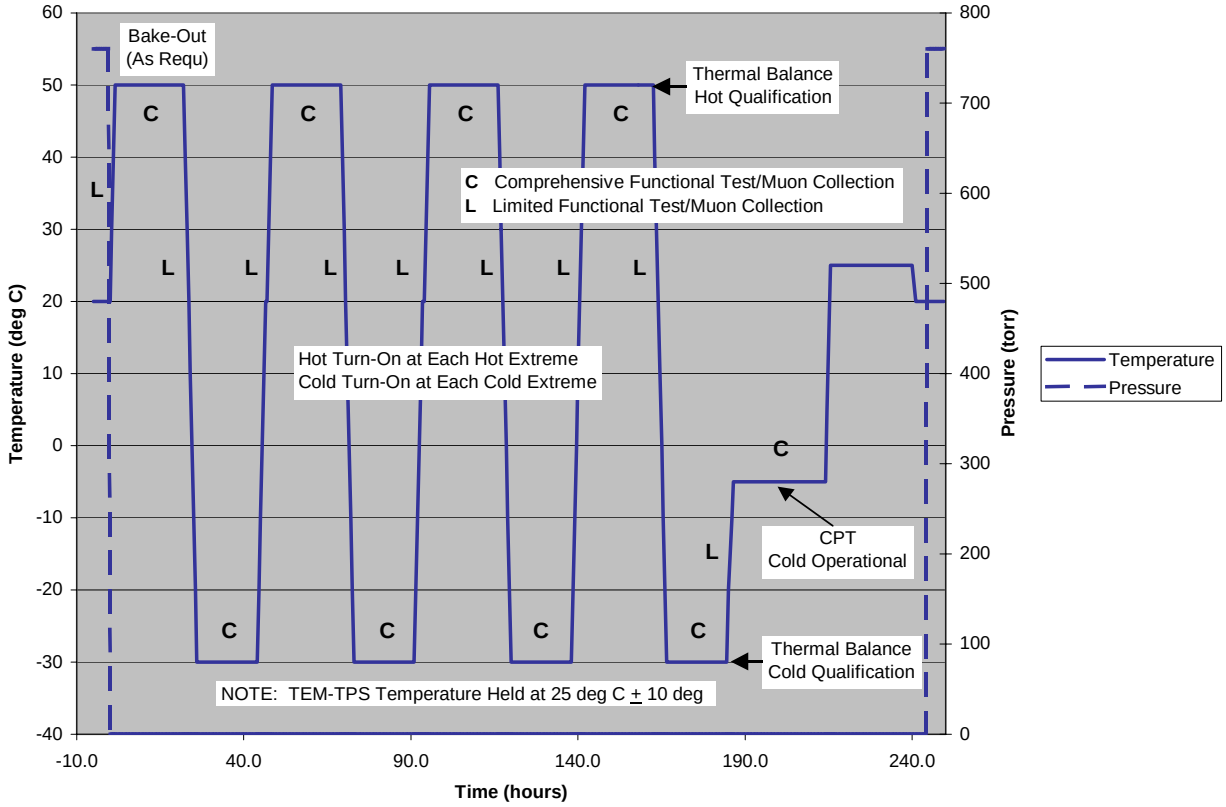


Figure 6-1: CAL Module Temperature Profile for Thermal Vacuum Testing – FM 101

Table 6-1: CAL Module Temperature Levels for Thermal Vacuum Testing – FM 101

TEST COMPONENT	QUALIFICATION LIMITS	
	COLD (deg C)	HOT (deg C)
CAL Module	-30	+50
TEM-TPS	+15	+35
CAL Cold Plate Assembly	-33	+50
TPS Cold Plate Assembly	+15	+35

Table 6-2: CAL Module Thermal Balance Control Points

Thermocouple	Component
TC 01 and 02	Top of Structure – Center of EMI shield
Thermal Balance Conditions Satisfied when Average Temperature of the Components are Stable within 0.1 °C per Hour	

6.2 FUNCTIONAL AND MUON TESTING DEFINITIONS

Throughout the TVAC Test, both limited and comprehensive electrical functional testing as well as muon performance testing was conducted on FM 101 in accordance with LAT-PS-01513, *CAL Functional Test and Calibration Procedure*.

6.2.1 Survival Turn-On Sequence

Survival turn-on sequence was performed at each hot survival plateau and cold survival plateau for thermal testing of the.

6.2.2 Limited Performance Testing of AFEE and TEM

Limited Performance Testing (LPT) verified selected elements of the electrical function of the AFEE and TEM electronics. This test was conducted during thermal transitions, where system failures or intermittent problems are most likely to occur.

6.2.3 Comprehensive Testing of AFEE and TEM

Comprehensive Performance Testing (CPT) verified the full electrical function of the AFEE and TEM electronics. This test was conducted at each hot and cold plateau of the thermal test cycles.

6.2.4 Cosmic Muon Test

Cosmic ray muons provide patterns of energy deposition in the CAL that are analogous to the flight science data. The muon test provides a limited end-to-end functional test of science data acquisition and science performance. The LPT and CPT contain brief muon data accumulations. Longer, dedicated muon accumulations were performed at the conclusion of the LPT or CPT while the CAL remains in each temperature plateau. This test was conducted throughout the test flow.

7 TEST SEQUENCE AND RESULTS

FM 101 was tested in accordance with LAT-PS-04455-02, *CAL Flight Module Thermal-Vacuum Test Procedure*, and work orders, WOA-01433 and WOA-01434. Temperature profile of all cycles are shown in Figure 7-1. Results and anomalies of each cycle are summarized in the following sections.

7.1 TVAC CYCLE 1

TVAC Cycle 1 started on October 1, 2004. During initial ramp to the hot case, the temperature of the CAL cold plate exceeded the maximum limit of +60 °C, as documented in problem report, PRB-0450. By the time the operator was able to manage the temperature of the cold plate, the base plate of FM 101 had reached +68 °C. Although the base plate temperature exceeded its test limit, the temperature of the temperature-sensitive components of the CAL module, AFEE and CDE, stayed within test limits. LPT, CPT, and muon collection occurred throughout the cycle according to the test schedule outlined in Section 6.5.1 of LAT-PS-04455-02.

7.2 TVAC CYCLE 2

TVAC Cycle 2 started on October 4, 2004. Temperature ramp and dwell for the hot was nominal. Required dwell time for the cold case was short since the cold soak profile was inadvertently initiated earlier than scheduled. Although most of the LPT, CPT, and muon collection occurred throughout the cycle according to the test schedule outlined in Section 6.5.2 of LAT-PS-04455-02, any tests that were missed were made up during TVAC Cycle 3.

7.3 TVAC CYCLE 3

TVAC Cycle 3 started on October 6, 2004. Temperature ramp and dwell were nominal. LPT, CPT, and muon collection occurred throughout the cycle according to the test schedule outlined in Section 6.5.3 of LAT-PS-04455-02.

7.4 TVAC CYCLE 4

TVAC Cycle 4 started on October 8, 2004. Temperature ramp and dwell for the hot case was nominal. During cold dwell, the CDACS temperature control software crashed while the liquid nitrogen solenoid valve to the TPS Cold Plate was in the open state. As a result, the TPS Cold Plate temperature exceeded its minimum limit of +15 °C, as documented in problem report, PRB-0451. By the time the operator was able to manage the temperature of the cold plate, temperature of the electronics for the EM2 TEM-TPS assembly had reached -50 °C. Although the TEM-TPS assembly exceeded its test limit, the temperature of the CAL module stayed within test limits. Since the TEM-TPS assembly is not flight equipment and continued to function after the anomaly, the test was continued. LPT, CPT, and muon collection occurred throughout the cycle according to the test schedule outlined in Section 6.5.4 of LAT-PS-04455-02.

Thermal Balance was achieved for the hot case at +49.2 °C and the cold case for –28.1 °C. Temperature profile during thermal balance activities are shown in Figure 7-2. More time was required to achieve thermal balance for the cold case since the cold soak profile was inadvertently initiated earlier than scheduled. Thermal balance was verified using the NRL

Hyman maneuver, as described in Section 5.3.2 and Section 6.5.4 of the As-Run Redlined version of LAT-PS-04455-02

7.5 COLD OPERATIONAL TEMPERATURE DWELL

Testing at the cold operational temperature started on October 13, 2004. Temperature ramp and dwell were nominal.

During this cycle, the LPT prematurely ended before completion of the test. This test error is a function of the current version of the LATTE software, which drives the CAL Module. As a result, all scheduled LPT could not be completed during this cycle, as documented in problem report, PRB-0445. With the exception of the LPT, the CPT and muon collection occurred during this temperature according to the test schedule outlined in Section 6.5.4 of LAT-PS-04455-02.

TVAC testing concluded on October 15, 2004.

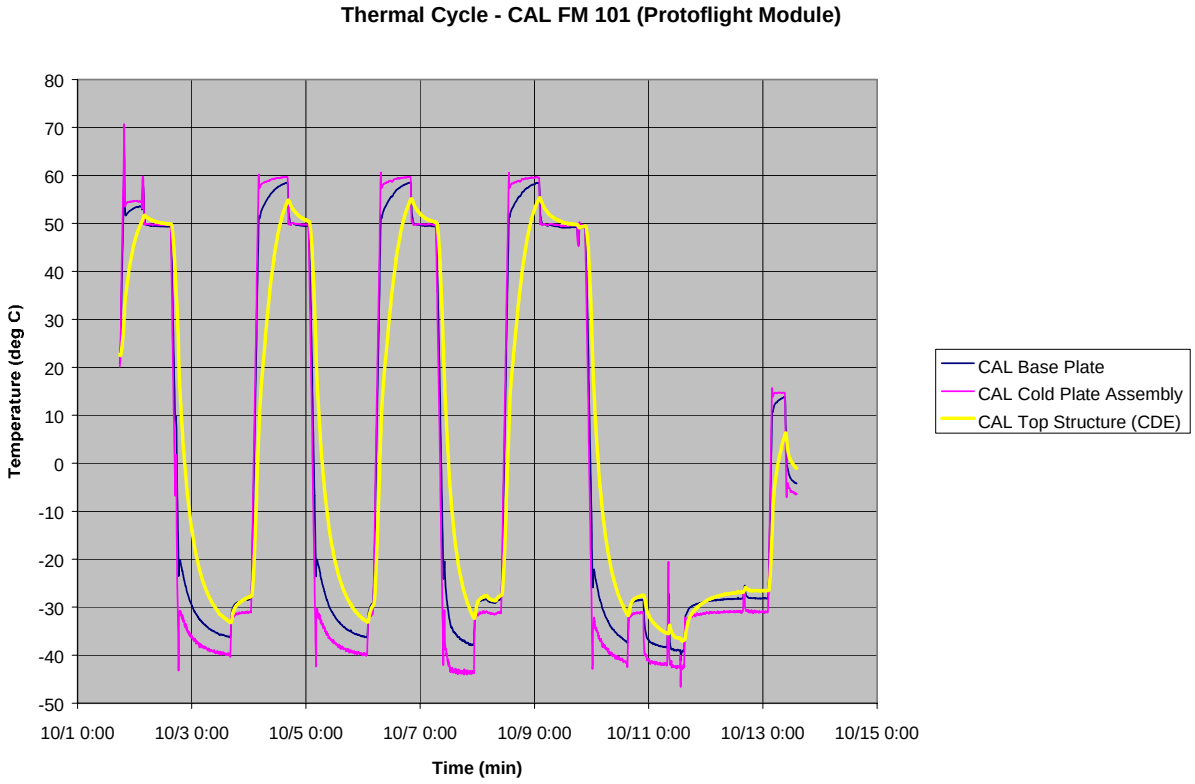


Figure 7-1: Temperature Profile of TVAC Cycles for FM 101

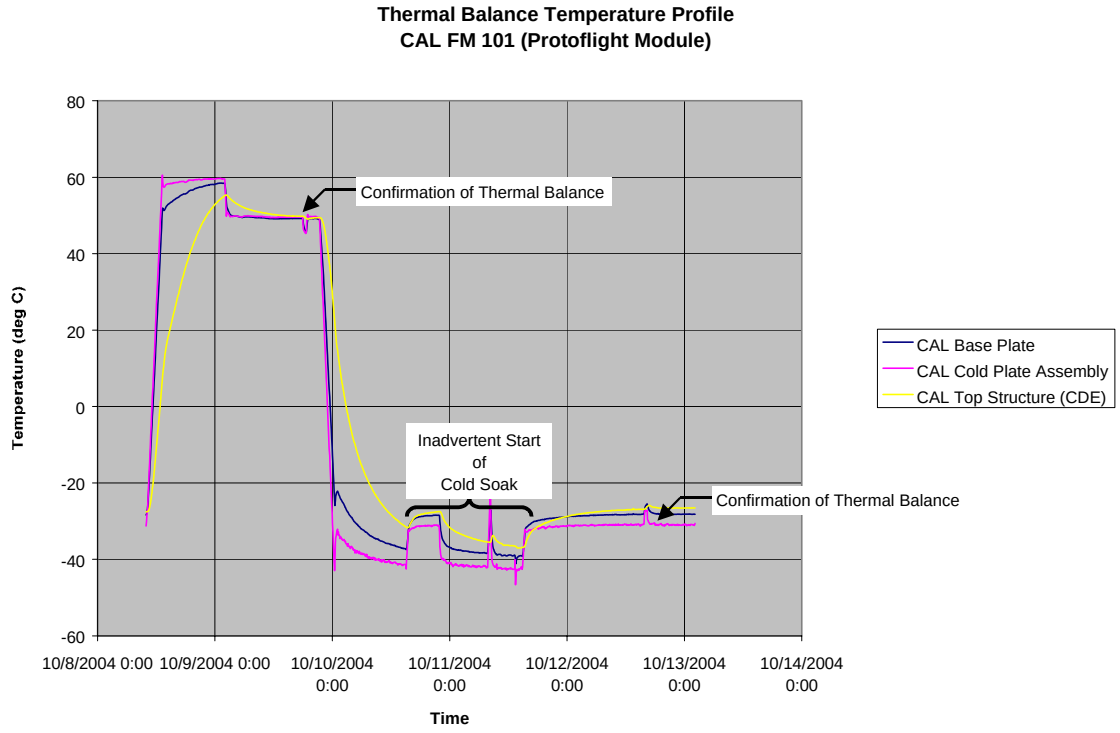


Figure 7-2: TVAC Cycle 4 - Thermal Balance of FM 101

8 CONCLUSIONS

The FM 101 CAL Module passed this series of TVAC testing since the following criteria, as specified in LAT-PS-04455-02, *CAL Flight Module Thermal-Vacuum Test Procedure*, were met:

- The environmental conditions and tolerances were applied in accordance to those described in Section 5.3.1 and Section 5.3.2 of LAT-PS-04455-02.
- Acquisition of thermal balance data was recorded and is suitable for correlation with the thermal models.
- Functional test data for the AFEE and TEM electronics was collected in accordance with, LAT-PS-01513, *CAL Functional Test and Calibration Procedure*.
- Cosmic muon test data was collected in accordance with, LAT-PS-01513, *CAL Functional Test and Calibration Procedure*.
- FM 101 incurred no detrimental damage or change in the electrical functional pass/fail status (CPT, LPT, and cosmic muon collection).